

**AMENDMENTS TO THE SPECIFICATION AND ABSTRACT**

*Please replace the original specification and abstract with the attached substitute specification and abstract.*

# SUBSTITUTE SPECIFICATION

## BALANCED TRANSMISSION APPARATUS



## BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a balanced transmission system and an apparatus related thereto that sends data using one pair or a plurality of pairs of conductors.

[0003] 2. Description of the Related Art

[0004] As an example, there is a power line communication system that sends data by superimposing a high frequency signal on a pair of metallic cables used for electric power transmission.

[0005] In such a case as sending data using one pair of metallic cables, EMC (Electromagnetic Compatibility) problems caused by the unbalance of a transmission line occur, as shown in Fig. 4.

[0006] These EMC problems include a leakage electric field induced by the metallic cables and extraneous noises coming into the metallic cables, both of which will deteriorate with increasing unbalance of the transmission line. These issues are described in detail in non-patent reference No.1 ("Problems and countermeasures for electromagnetic noises in telecommunication systems", Takeshi Ideguchi, et al., Morikita Shuppan, November 25, 1997, pp. 99 - 134).

[0007] In a balanced transmission system, complete balance is fundamentally required from a transmitting unit to a receiving unit. However, the complete balance is not realized due to the presence of unbalanced elements in transmitting and receiving circuit units or unbalance components on the transmission line.

[0008] Such unbalanced components in the transmission line may cause EMC problems, affecting other systems due to the leakage electric field or deteriorating performance of power line communication systems due to extraneous noises.

## SUMMARY OF THE INVENTION

[0009] In view of the above, an object of the present invention is to reduce the effect of EMC problems caused by the unbalance of the power transmission line.

[0010] In a first aspect of the invention and a second aspect of the invention, either or both of electric voltage or electric current applied to each of a pair of conductors are monitored and the electric power or the electric current to be applied is controlled according to the monitored values.

[0011] This structure makes it possible to keep the balance at a transmitting point without depending on the degree of balance of the transmission line, thus reducing EMC problems in a transmitter.

[0012] In a third aspect of the invention, either or both of electric voltage or electric current output from each of a pair of conductors at a receiver are monitored and their status will be output.

[0013] With this structure, the balance status in the receiver may be evaluated.

[0014] In fourth and fifth aspects of the present invention, in addition to the third aspect described above, an output signal of a receiving condition output unit in the receiver is fed back to a transmitter, thereby either or both of electric voltage or electric current applied to each conductor will be controlled according to the fed-back output signal.

[0015] With this structure, the degree of balance in the receiving unit may be improved, thus serving to reduce EMC problems in the receiver.

[0016] From sixth to eighth aspects of the present invention, either or both of electric voltage or electric current applied to each of a pair of conductors is monitored in a transmitter, and either or both of electric voltage or electric current output from each of a pair of conductors at a receiver are monitored and their status output. Then either or both of electric voltage or electric current to be applied to each of a pair of conductors in the transmitter are controlled according to the monitored status.

[0017] With this structure, it may be possible to improve a degree of balance in the receiver while keeping the balance in the transmitter, thus serving to reduce EMC

problems both in the transmitter and the receiver.

[0018] The above, and other objects, features and advantages of the present invention will become apparent from the following description read in conjunction with the accompanying drawings, in which like reference numerals designate the same elements.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Fig. 1 is a block diagram illustrating a transmitter of a balanced transmission apparatus according to a first embodiment of the present invention.

[0020] Fig. 2 is a block diagram illustrating a transmitter and a receiver of a balanced transmission apparatus according to a second embodiment of the present invention.

[0021] Fig. 3 is a block diagram illustrating a transmitter and a receiver of a balanced transmission apparatus according to a third embodiment of the present invention.

[0022] Fig. 4 is a diagram illustrating effects of EMC problems in a prior art balanced transmission system.

#### DETAILED DESCRIPTION OF THE INVENTION

[0023] Preferred embodiments of the present invention will be described in conjunction with the accompanying drawings.

[0024] (Embodiment 1)

[0025] Fig. 1 is a block diagram illustrating a transmitter of a balanced transmission apparatus according to a first embodiment of the present invention.

[0026] As illustrated in Fig. 1, the transmitter according to the first embodiment of the present invention comprises a transmitting signal monitoring unit 11 and a transmitting signal control unit 12, wherein the balanced data to be sent is first input into the transmitting signal control unit 12, and thereafter applied to a conductor 1 and a conductor 2 through the transmitting signal monitoring unit 11.

[0027] In this example, the degree of balance of the balanced data signal applied to the conductor 1 and the conductor 2 will be improved by using the apparatus in Fig. 1.

[0028] In Fig. 1, the balanced data input into the transmitting signal control unit 12 is a

differential signal that is converted from an unbalanced signal into a balanced signal by such an unbalance-balance converter as represented by an unbalance-balance converting transformer called a balun or a differential driver circuit, etc. Although this differential signal is assumed to be balanced perfectly, there is no problem in practice if the balance is not kept perfectly.

[0029] In the transmitting signal control unit 12, either a voltage value or a current value, or both values of the output will be changed so that the degree of balance for the differential signal input may be improved.

[0030] The differential signal output from this transmitting signal control unit 12 will be applied to conductor 1 and conductor 2 through the transmitting signal monitoring unit 11. At this time, the signal applied to the conductors may have a different value from the value output from the transmitting signal control unit 12, according to the transmitting impedance of the transmitter and the transmitting line impedance (impedance of the conductors and of all the elements connected to the conductors). In this case, the degree of balance may deteriorate, although the transmitting signal control unit 12 has made adjustment in order to improve the degree of balance.

[0031] Thereby, either the voltage value or the current value, or both values actually applied to the conductors are monitored by the transmitting signal monitoring unit 11 and the signal level actually applied to the conductors are fed back to the transmitting signal control unit 12 (i.e., a broken line in Fig. 1). Using this feedback signal, the transmitting signal control unit 12 controls either the voltage or the current, or both so that the degree of balance of the signal actually applied to the conductors may be improved.

[0032] Consequently, the transmitting signal level to be actually applied to the conductors will be controlled according to the transmission line status. As a result, the degree of balance will improve.

[0033] In the above example, controlling the transmitting signal level with a regular

feedback has been described. Determining the transmitting signal level with an initial feedback signal is also effective.

[0034] (Embodiment 2)

[0035] Fig. 2 is a block diagram illustrating a transmitter and a receiver of a balanced transmission apparatus according to a second embodiment of the present invention.

[0036] As illustrated in Fig. 2, the receiver according to the second embodiment of the present invention comprises a receiving signal monitoring unit 23 and a receiving status output unit 24. The transmitter includes a transmitting signal control unit 22, wherein balanced data to be sent is initially input into a transmitting signal control unit 22, and thereafter applied to a conductor 1 and a conductor 2.

[0037] In this example, the degree of balance of a balanced data signal from the conductor 1 and conductor 2 in a receiver will be improved by using the apparatus of Fig. 2.

[0038] In the receiver, a signal received from conductor 1 and conductor 2 connected to the receiver will be received through the receiving signal monitoring unit 23. The receiving signal monitoring unit 23 has a function to detect either the voltage value or the current value, or both values of the received signal, and to output the detected result to the receiving status output unit 24.

[0039] In the balanced transmission system according to the present embodiment, a signal sent through conductor 1 and conductor 2 as medium is a differential signal; therefore, the sum of the signal outputted from each conductor makes a fixed bias value. Fundamentally, this bias value is one applied in a transmitter, and can be specified. If the sum of the signal monitored in the receiving signal monitoring unit 23 is found to be different from the bias value applied in the transmitter, it means that a common mode signal is applied by some reasons. Generally, this is due to the unbalance of the transmission line. Accordingly, the receiver according to the present embodiment comprising the receiving signal monitoring unit 23 may evaluate the balance of the

transmission line.

[0040] Furthermore, Fig. 2 also illustrates an example including a function to feedback the detected result by the receiving signal monitoring unit 23 into the transmitter through the receiving status output unit 24. At this time, the feedback signal is transferred to the transmitting signal control unit 22 in the transmitter, which makes it possible to control the transmitting signal according to the balance evaluated at the receiving signal monitoring unit 23. For example, if a value that is different from the bias value applied in the transmitter is detected in the receiving signal monitoring unit 23, the detected value is transferred to the transmitting signal control unit 22 in the transmitter. Then, the transmitting signal control unit 22 controls so as to decrease the difference between the bias value and the detection value detected by the receiving signal monitoring unit 23. As a result, the degree of balance in the receiver may be improved.

[0041] (Embodiment 3)

[0042] Fig. 3 is a block diagram illustrating a transmitter and a receiver of a balanced transmission apparatus according to a third embodiment of the present invention.

[0043] As shown in Fig. 3, in the balanced transmission apparatus in accordance with the third embodiment, balanced data is sent by the transmitter which comprises a transmitting signal monitoring unit 31 and a transmitting signal control unit 32, and is received by the receiver which comprises a receiving signal monitoring unit 33 and a receiving state output unit 34. The balanced data to be sent is first input into the transmitting signal control unit 32, thereafter applied to a conductor 1 and a conductor 2 through the transmitting signal monitoring unit 31. The signal sent through conductor 1 and conductor 2 as medium is received by the receiving signal monitoring unit 33. The receiving signal monitoring unit 33 has a function to output either the voltage value or the current value, or both values of the received signal, which will be output from the receiving status output unit 24.

[0044] In this example, the degree of balance of the balanced data signal applied to conductor 1 and conductor 2 will be improved by using the apparatus in Fig. 3.

[0045] In Fig. 3, balanced data to be sent is first input into the transmitting signal control unit 32, thereafter applied to conductor 1 and conductor 2 through the transmitting signal monitoring unit 31. The operation of the transmitter according to the present embodiment is the same as in the first embodiment. The signal level to be actually applied to the conductors is monitored by the transmitting signal monitoring unit 31, and according to the signal level, the signal output from the transmitting signal control unit 32 is controlled. This feature is effective to improve the degree of balance in the transmitter, as in the first embodiment.

[0046] Next, the operation of the receiver will be described. A signal transmitted through conductor 1 and conductor 2 as a medium is received through the receiving signal monitoring unit 23. The receiving signal monitoring unit 23 functions to output either the voltage value or the current value, or both values of the received signal, and the value will be output from the receiving status output unit 24. The operation is the same as in the second embodiment, wherein the signal output is controlled by the transmitting signal control unit 32 of the transmitter so that a common mode signal level detected by the receiving signal monitoring unit 23 may become small. This feature is effective to improve the degree of balance in the receiver as in the second embodiment.

[0047] The two kinds of operations mentioned above may improve the degree of balance both in the transmitter and the receiver.

[0048] The transmitting signal control unit 32 receives two feedback signals, the signal from the transmitting signal monitoring unit 31 and the signal from the receiving status output unit 24. Therefore, the degree of balance of a transmitter is controlled to improve, for example, the degree of balance the receiver may deteriorate. In this case, threshold values are provided with the signal from the transmitting signal monitoring unit 31 and the signal from the receiving status output unit 24. The threshold values may be



determined by the allowance for the degree of balance of the transmitter or the degree of balance of the receiver. Each allowance for the degree of balance may be determined by the allowance for a leakage electric field level. For example, when controlling the transmitting output in the transmitting signal control unit 32 according to the signal of the transmitting signal monitoring unit 31, the sum of the signal levels applied to conductor 1 and conductor 2 is assumed to be the same as the bias value. This means that the degree of balance is high enough in the transmitter. However, in this case, the sum of the signal levels of conductor 1 and conductor 2 may be different from the bias value in the receiver. When different, whether the difference exceeds the threshold value or not will be checked. When the difference does not exceed the threshold value, the leakage electric field of the whole system is judged to be small. When the difference does exceed the threshold value, the transmitted output will be controlled by the transmitting signal control unit 32 in order to make the difference approach the threshold. As a result, although the degree of balance in the transmitter deteriorates, the degree of balance in the receiver improves. Thus, making both differences approach the corresponding threshold values improves the degree of balance of the whole system, which may result in reducing leakage electric fields.

[0049] In the above explanation, the configuration of the system is assumed to comprise one transmitter and one receiver. The same effect will be acquired for a system comprising a plurality of transmitters and receivers.

[0050] In conclusion, the present invention makes it possible to keep the balance at a transmitting point without depending on the degree of balance of a transmission line, which results in reducing EMC problems in a transmitter.

[0051] The present invention also makes it possible to improve the degree of balance in a receiving point, while evaluating the balance in a receiver, which results in reducing EMC problems in the receiver.

[0052] Combining the two features mentioned above enables the degree of balance to be

improved both in the transmitter and the receiver, which results in reducing EMC problems in the whole balanced transmission system.

[0053] Having described preferred embodiments of the invention with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention as defined in the appended claims.